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## **Polarization properties of chiral-core planar waveguides**

Presenter: Warren N. Herman

Address: US Navy, NAWCAD  
EO Sensors Division AIR456  
Patuxent River, MD 20670

### **Abstract**

A new form for the modal eigenvalue equations of chiral-core planar waveguides provides insight into the transition, with increasing chirality, from TE/TM (transverse electric/magnetic) modes in the achiral case to nearly right-handed and left-handed circularly polarized modes. Dramatic variation of the polarization eccentricity with thickness and frequency is discussed.



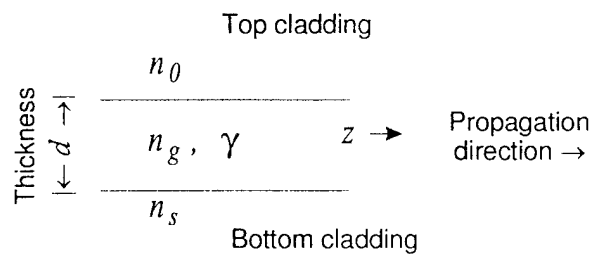
## Polarization Properties of Chiral Core Planar Waveguides

W.N. Herman  
U.S. Navy, NAWCAD  
EO Sensors Division, Patuxent River, MD

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15-17 October 2001



## Chiral Core Optical Waveguides



### ISOTROPIC CHIRAL MEDIUM

Constitutive Relations  
(Drude-Born-Federov)

$$\vec{D} = \epsilon(\vec{E} + \gamma \nabla \times \vec{E}) \quad \vec{B} = \mu(\vec{H} + \gamma \nabla \times \vec{H})$$

Bohren's Decomposition

$$\vec{E} = \frac{1}{2}(\vec{F}^+ + \vec{F}^-) \quad \vec{H} = \frac{1}{2i} \sqrt{\frac{\epsilon}{\mu}} (\vec{F}^+ - \vec{F}^-)$$

Wave Equation

$$\nabla^2 \vec{F}^\pm + (k_0 n_\pm)^2 \vec{F}^\pm = 0$$

Eigenmodes in bulk  
material circularly polarized

$$\vec{F}^\pm = \vec{E}_0 e^{i(k_0 n_\pm z - \omega t)} (\hat{x} \pm i\hat{y})$$

Refractive indices  
for RH and LH  
waves

$$n_\pm = \frac{n_g}{1 \pm \delta} \quad \delta = k_0 n_g \gamma \quad n_g = \sqrt{\frac{\epsilon}{\epsilon_0}} \quad k_0 = \frac{2\pi}{\lambda}$$

Rotatory Power

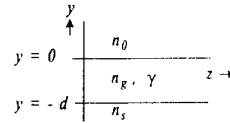
$$\rho = \frac{\pi(n_- - n_+)}{\lambda} \approx k_0 n_g \delta$$

A. Lahtakia, V.K. Varadan, and V.V. Varadan, Time-Harmonic Electromagnetic Fields in Chiral Media, Lecture Notes in Physics Series 335 (Springer-Verlag, Berlin, 1989).  
I.V. Lindell, A.H. Sihvola, S.A. Tretyakov, A.J. Viitanen, Electromagnetic Waves in Chiral and Bi-isotropic Media, (Artech House, Norwood, MA, 1994).

### Modes in Chiral Asymmetric Waveguide

W. N. Herman, accepted *J. Opt. Soc. Am. A*

$$\vec{F}^\pm(y, z) = \vec{\Psi}^\pm(y) \exp(-ik_0 n_{eff} z)$$



Modal equations: (3 equations to be solved simultaneously for  $n_{eff}$ ,  $g$ ,  $h$ )

$$u^\pm d = \cot^{-1} \left( \sigma_0^\pm \frac{r_0 \pm g}{1 \pm g} \right) + \cot^{-1} \left( \sigma_s^\pm \frac{r_s \pm h}{1 \pm h} \right) + m^\pm \pi$$

$$h(g, n_{eff}) = \frac{(S_{r_0}^+ - S_{r_0}^-) + (S_0^+ + S_0^-)g}{(S_{r_0}^+ + S_{r_0}^-) + (S_0^+ - S_0^-)g}$$

$$S_0^\pm \equiv \sigma_0^\pm \sin(u^\pm d) \mp \cos(u^\pm d)$$

$$S_{r_0}^\pm \equiv r_0 \sigma_0^\pm \sin(u^\pm d) \mp \cos(u^\pm d)$$

$$\sigma_0^\pm \equiv (1 \pm \delta) \frac{u^\pm}{v}, \quad \sigma_s^\pm \equiv (1 \pm \delta) \frac{u^\pm}{w}, \quad r_0 \equiv \frac{n_0^2}{n_g^2}, \quad r_s \equiv \frac{n_s^2}{n_g^2}$$

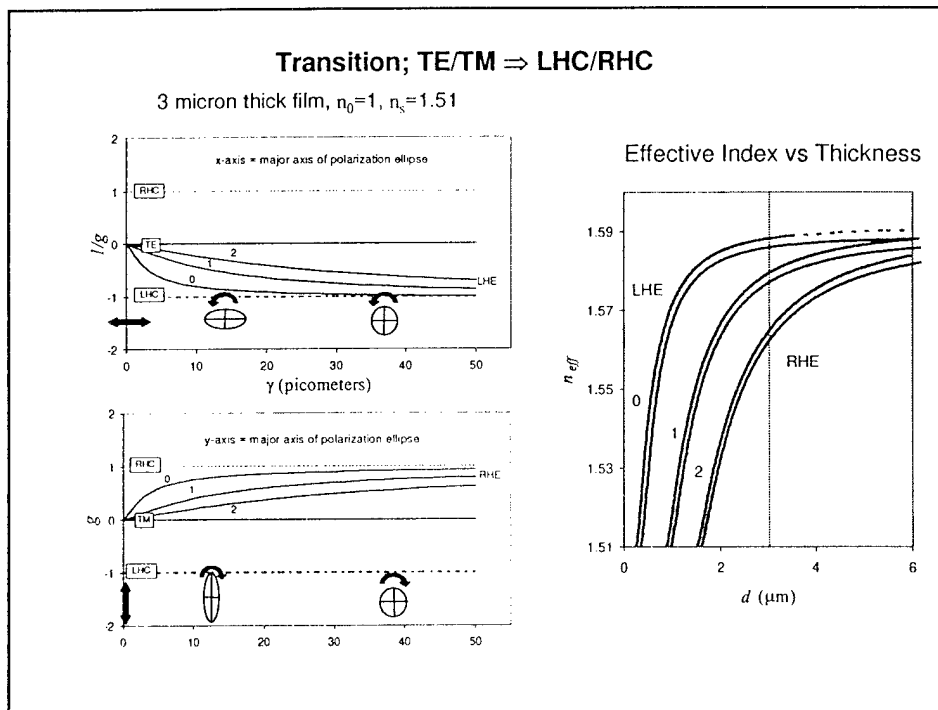
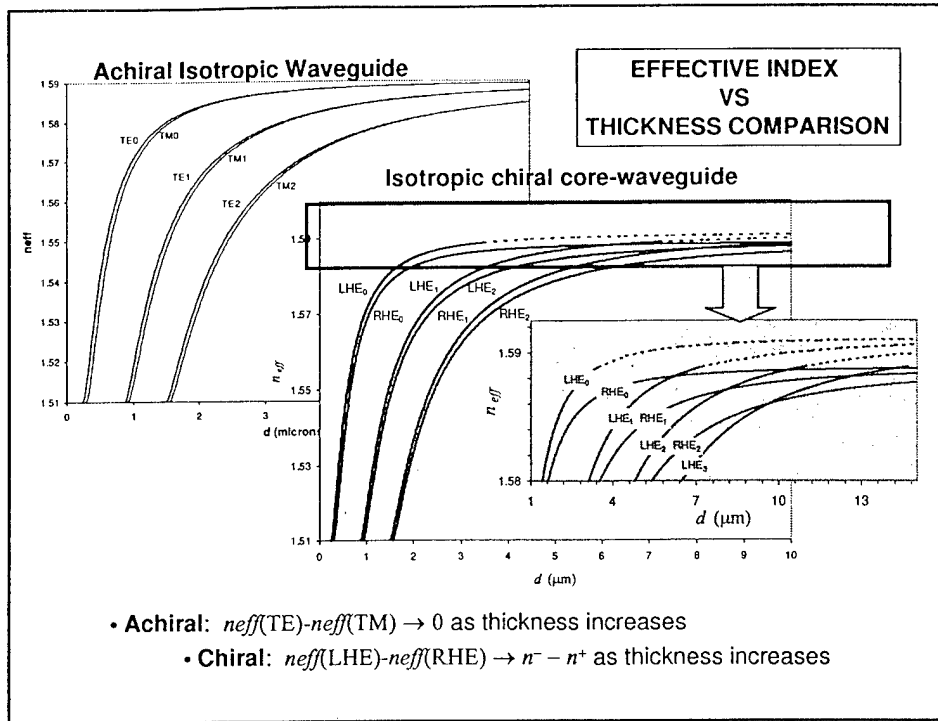
$$u^\pm \equiv k_0 \sqrt{n_t^2 - n_{eff}^2}, \quad v \equiv k_0 \sqrt{n_{eff}^2 - n_0^2}, \quad w \equiv k_0 \sqrt{n_{eff}^2 - n_s^2}$$

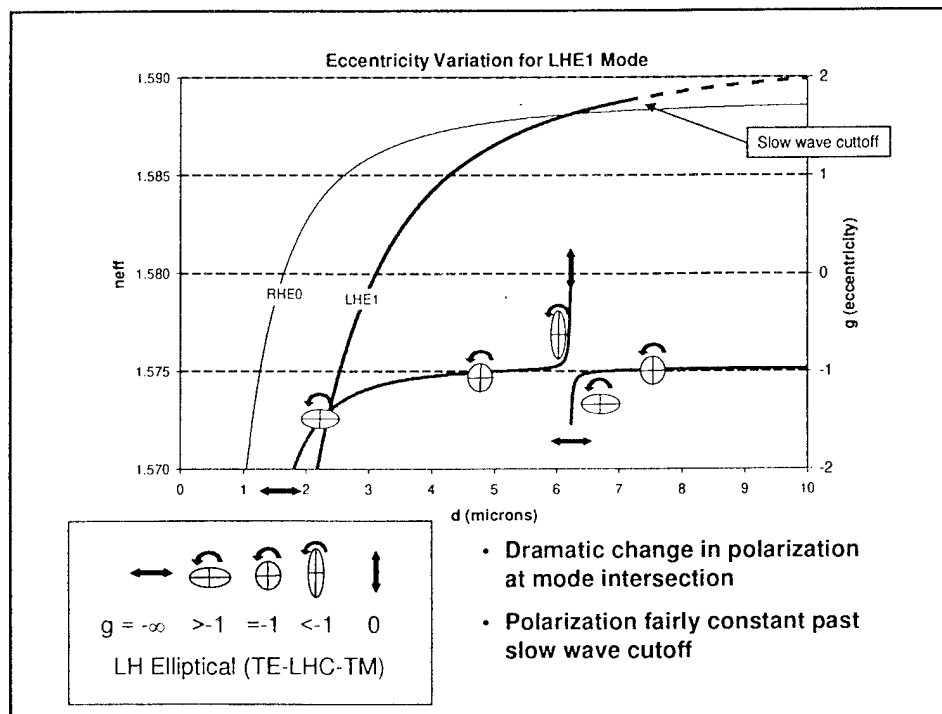
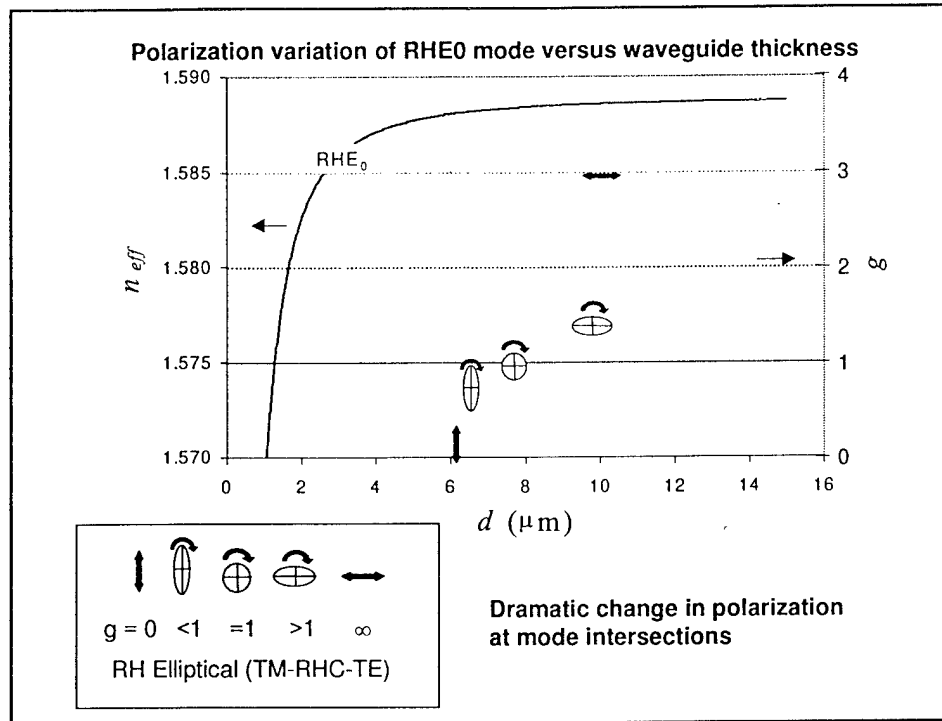
$$n^\pm = \frac{n_g}{1 \pm \delta}$$

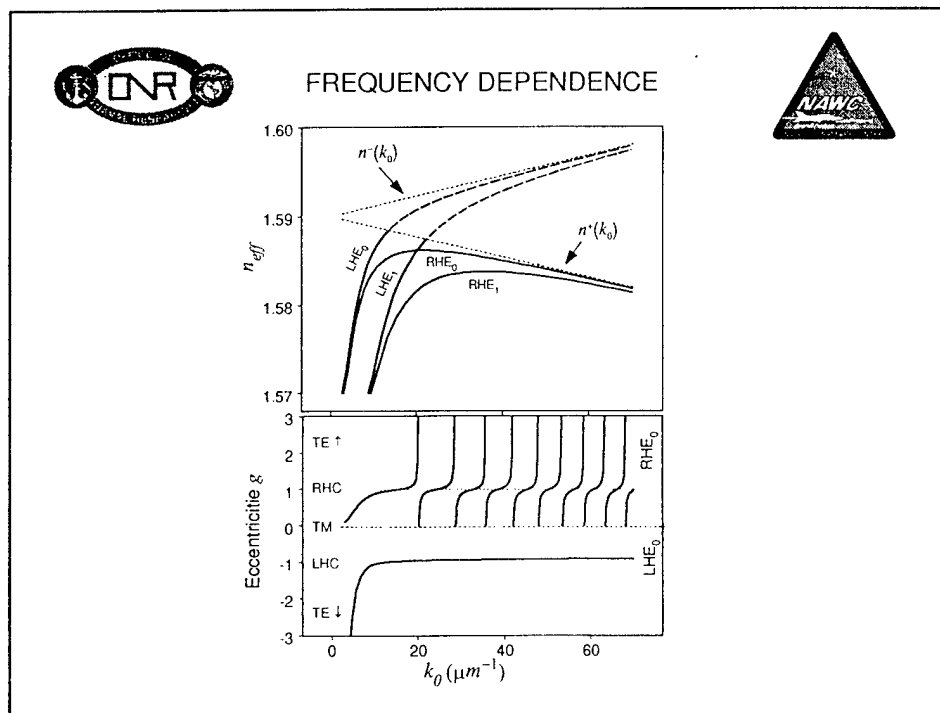
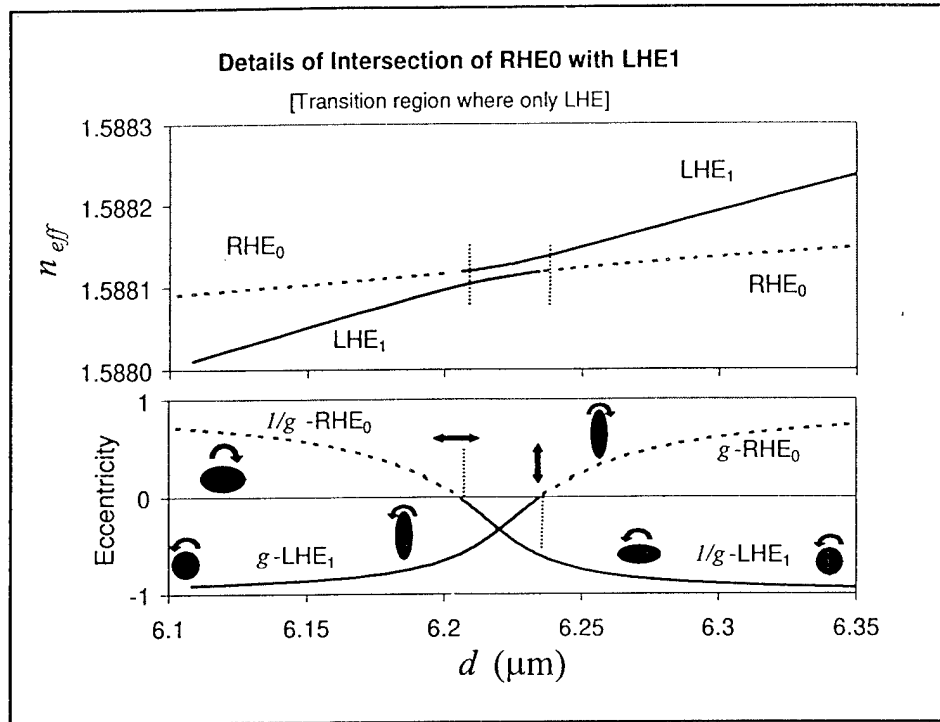
Parameters  $g$ ,  $h$  determine eccentricity of polarization ellipse for transverse E-field:

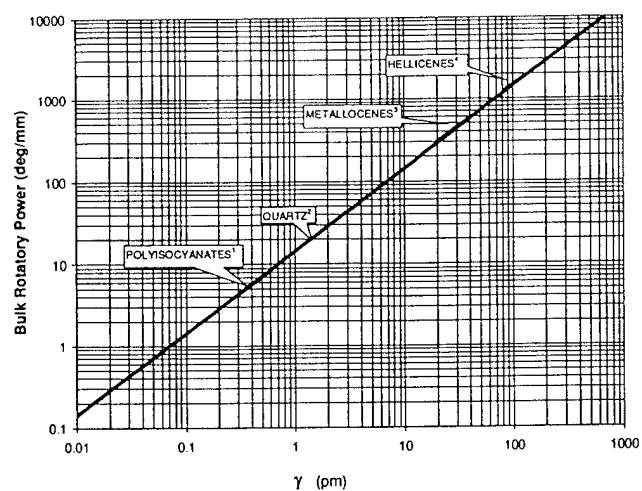
$$\left. \frac{E_x}{E_y} \right|_{y \geq 0} = i \frac{n_{eff}}{n_g} \frac{1}{g}$$

$$\left. \frac{E_y}{E_x} \right|_{y \leq -d} = i \frac{n_{eff}}{n_g} \frac{1}{h}$$









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